STATE ENGINEERING EXPERIMENT STATION

The Research Engineer

GEORGIA INSTITUTE OF TECHNOLOGY

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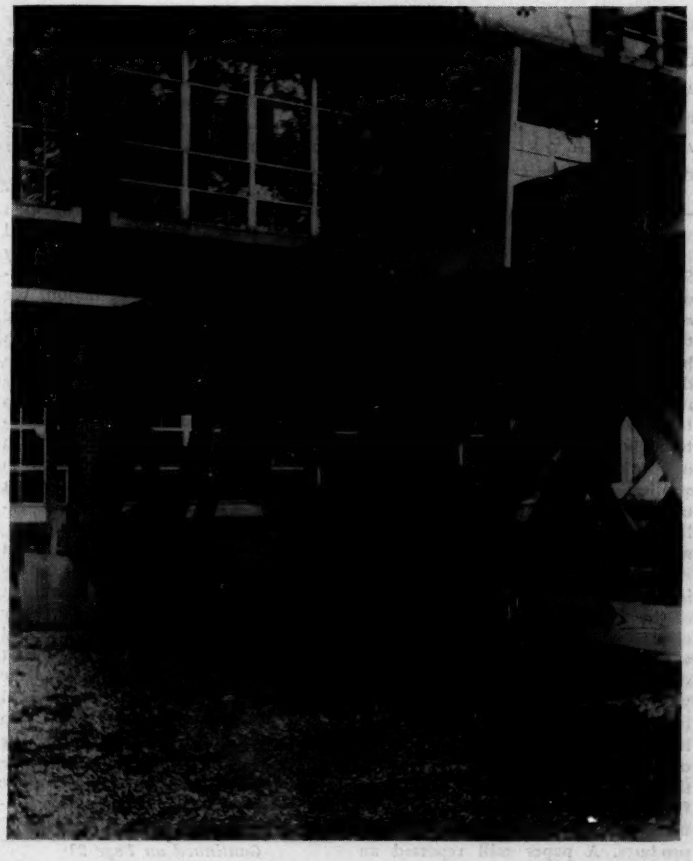

The Research Engineer

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SELLING RESEARCH

Selling new ideas to people who are convinced that they are operating successfully with old ideas is not an easy task. Yet, in essence, that is what must be done to acquire the funds for industrial research. Each request for a research appropriation, whether it be for $10,000 or $100,000, must be backed by a clear statement of objective, plan of attack and possibilities for profitable application. The company quite naturally wants to know what return it has reason to expect from an investment in research.

Actually, recently reported statistics indicate that industrial research is one of the finer fields for investment. One oil company showed a seven-year average profit of $1.35 for every dollar spent on research. Another oil company estimated that each research dollar yielded $15.40 broken down as follows: $3.70 as savings in royalties which otherwise would have been paid to outside groups; $9.60 as profits resulting from process and product improvements; and $2.10 as profits from new products. A paper mill reported an estimated annual return of $10 per dollar expended on research. These and many, many other companies are already sold on the value of research—as witness the fact that industry's annual expenditure for research has averaged about $700,000,000 in the postwar period.

However, there is a much more important job of selling to be done. Upon its successful accomplishment depend our country's industrial and military growth and, ultimately, even her continued existence as a free nation. We refer, of course, to the selling of basic research, obtaining funds for research that has no set goal other than replenishing our storehouse of fundamental knowledge. That certainly is goal enough, since it is only by application of knowledge obtained through basic research that we can continue to create the machines and products that will maintain the United States' superiority in peace and in war.

What value can be placed on a given basic research project? No satisfactory answer can be given because we do not know how the knowledge sought may be applied. For example, who would have dreamed in the 20's and 30's that the relatively small amount of basic research being conducted in the field of nuclear physics would blossom into a $2 billion atom bomb project by the 40's? And who can say now what nuclear energy may mean in the future to a world rapidly exhausting its mineral fuel resources?

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UNIVERSITIES AND THEIR RELATIONSHIP TO RESEARCH AND DEVELOPMENT

By BLAKE R. VAN LEER*

Col. Van Leer was recently invited by the Industrial College of the Armed Forces to present a lecture to its students on the place of universities in the nation's research and development effort. Although originally directed to an audience of high ranking officers and selected men from the upper echelons of government organizations, his lecture covered subjects which we believe will prove of great interest to all of our readers who are desirous that our country maintain and improve its position of industrial and military leadership.

Blake R. Van Leer

Gentlemen, it is not often that a university president can corner a high ranking audience like this just to hear him talk. But from what I am told of your studies here, I gather that you are as vitally interested in the problems of research and research manpower as we are at Georgia Tech. I would like to tell you something about these problems, as we in the universities see them, and attempt to outline the university's position in the changing pattern of research and development.

Change is about the only certain thing in this dynamic world of ours—tomorrow is always different from today. Today's problems have to be solved from the knowledge and experience accumulated during many yesterdays. So that we will be prepared to deal with tomorrow's problems, it behooves us to look forward today. This function of preparing for tomorrow through study of the past, creative thought in the present, and guided prediction of the future is, by and large, the province of the educational institutions.

How do we prepare men to be creative thinkers and planners? To answer this question, let us take a brief look at our educational system.

First, we have the grade schools. Here, from kindergarten through the eighth grade, a child is supposed to learn to read, to count, and to write. In other words, he acquires just about the minimum amount of knowledge for existence in the world today.

Second is the high school, where again the child is taught only what are supposed to be well-known and established facts. There are few controversial or speculative things introduced here. He should learn to read rapidly and comprehensively, to express himself in writing with considerable facility, to solve mathematical problems by the use of higher arithmetic, algebra, and geometry, to learn the basic facts of history and the fundamental political institutions of his country, to learn something of the geography and governments of the world, and to lay the groundwork for a vocation. Upon graduation, the boy should have the minimum education for earning a living and fulfilling the duties of citizenship.

Third, we have the liberal arts college. Here the youth is expected to acquire a more mature and masterful comprehension of all he has previously learned, to develop the ability to study and discuss intelligently various controversial theories and hypotheses, and to secure either a broad general education or a specific foundation for subsequent graduate and professional studies.

Finally, there are the universities and the professional schools. Here the student's education is broadened or changed substantially, and numerous routes are open to him. It is not necessary to enumerate the many subjects he may choose, the career he may decide to follow, or the degrees he may attain. But if he plans to become a research scientist, he may start from almost any Bachelor specialization, following it with some specialization toward a Master's degree and working toward the ultimate goal of a doctorate. The specifications for a Ph.D.

*President, Georgia Institute of Technology

are varied, of course, depending on the field of specialization. But one prerequisite is recognized as standard—the ability to plan and execute independent research.

We see, then, that in the universities and professional schools the research scientist is incubated, cultured, and trained for his future work. Research is the thing that sets these institutions apart from the grade schools, the high schools, and the liberal arts colleges. The latter deal almost exclusively with known or accepted knowledge, while the universities push on into the realm of the speculative and the unknown, seeking to acquire new knowledge for application to tomorrow's problems. This is the atmosphere that breeds researchers.

I need not expound the importance of research to technological progress, since we are all agreed on that score or we would not be together here today. However, I would like to point out that graduate-level education is as essential to research as research is to progress. Graduate programs provide both the raw material and the manpower for the prosecution of research. By "raw material" I mean the new concepts and basic data emanating from pure research conducted by candidates for advanced degrees and by the high-grade faculty members engaged in graduate education. These concepts and data serve as grist for the mills of the applied researchers. As mentioned, the graduate programs of our universities are the breeding ground of the research scientist and engineer. It is here that young men learn the methods of research—those techniques which they will employ in later years to advance the frontier of scientific knowledge.

Before discussing the university's position and problems in the changing pattern of research and development, we might review briefly how that pattern has changed. Immediately prior to World War II, there were about 45,000 persons engaged in all types of research in the United States. The total national expenditure for research was about $350 million, much of it spent by a relatively few forward-looking industries such as the petroleum industry and the chemical industry. University research, though limited rather severely by lack of funds, was then, as now, the primary source of basic research. There was also a growing appreciation of the value of non-profit research institutions, largely as the result of the demonstrated success of Mellon Institute, founded in 1911, Battelle Memorial Institute, established in 1929, and Armour Research Foundation, a newcomer in 1936 but already making itself heard. Armed Forces expenditures for research and development in 1940 amounted to about $22 million, approximately one-fifteenth of the national total.

Then came World War II and an unprecedented growth in our research effort. As of 1945, the military research expenditure had increased to $600 million, and the national total to $1.1 billion.

In the five peacetime years prior to the Korean incident, the military research and development budget, exclusive of atomic energy, averaged about $500 million per year, and industrial research about $800 million.

The pattern changed again following the outbreak of hostilities in June, 1950. At present the military research and development program is running about $1.1 billion annually with a further increase of about $200 million expected in 1952. Our total national research effort is variously estimated at $1.75 to $2.3 billion, so we can see that military research now constitutes somewhere between 48 and 63 per cent of the total research expenditure, as compared with slightly over 6 per cent in 1940. The total national expenditure for research is now five to six and one-half times as great as it was just before World War II. The military expenditure has increased fifty-fold. I believe you will agree that we are safe in speaking of the "changing" pattern of research and development.

What has been the impact of this change on the nation as a whole and the universities in particular? First of all, as might be expected, it has created a drastic shortage of research manpower. We have already seen that there were some 45,000 persons engaged in research in 1940. Today, there are roughly 130,000 or about three times as many. However, the research load, on an expenditures basis, is around six times that in 1940.

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APPLICATIONS OF THE ELECTRON MICROSCOPE

By L. A. WOODWARD*

Last March Prof. Woodward described the electron microscope's construction and the principles involved in its operation. Here he illustrates some of its applications with a number of electron micrographs prepared during studies conducted at Georgia Tech Engineering Experiment Station.

The electron microscope offers two major advantages over the optical microscope: superior resolving power providing greater useful magnification and a greater depth of focus yielding better micrographs.

As explained in the previous article, the useful magnification of the optical microscope is limited to about 1000 diameters by the wave nature of the visible light used to illuminate the sample. The relative "coarseness" of visible light renders even the best optical microscope incapable of forming a clear image of objects smaller than about six millionths of an inch. In addition, the optical microscope's depth of focus becomes very small at high magnifications, which means that micrographs (photographs made through the microscope) are not very satisfactory. At high magnifications, more information generally can be obtained by looking directly at the sample through the microscope than by making a micrograph.

On the other hand, the electron microscope uses a beam of electrons as its illumination medium which exhibits a much shorter wave-length characteristic than visible light and thus permits considerably greater resolution of fine detail. This extends its usable range of direct magnification to a maximum of about 22,000 X, or some 20 times that of the optical microscope. Since the electron microscope's depth of focus is also comparatively large, much better micrographs can be made than with the optical microscope. When fine-grained film is used, the micrographs can be enlarged by normal photographic processes—in some cases to as much as 200,000 times the size of the particles observed.

Use of the electron microscope also has its disadvantages. More elaborate specimen preparation is usually necessary; and, since the sample must be viewed in a vacuum and must be bombarded by electrons, many materials cannot be examined at all or only by indirect means.

With the foregoing as a brief introduction, the remainder of this article will be devoted to discussion of the electron microscope's applications, illustrating them with a number of micrographs prepared in the course of studies conducted at the Georgia Tech Engineering Experiment Station. Since kaolin mining and processing ranks first in the mineral activities of Georgia, with the state producing about 80 per cent of the nation's supply, it is fitting that the first four micrographs picture this clay. However, they have not been selected primarily for this reason, but rather because they demonstrate the increased resolving power of the electron microscope as compared with the optical microscope.

Figure 1. Optical micrograph of kaolin shown at magnification of 535 X.

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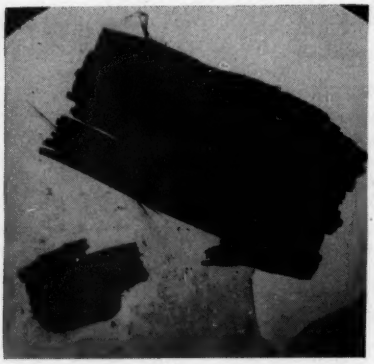

Figure 2. Electron micrograph of kaolin shown at magnification of 6,500 X.

Figure 2a. The same kaolin particle (as in Fig. 2) after rotation through about 90°.

Determination of Structure

Figure 1 shows some fairly large kaolin particles (about 1/1000 inch in diameter) as they appear in a micrograph made with an optical microscope at a magnification of 535 X. It reveals the gross nature of the particles but gives little information on the structure of the pieces. An optical micrograph taken at a greater magnification would make the pieces look larger but would not give any substantial increase in information on structure, since the particles are too fine for detailed resolution by the optical microscope.

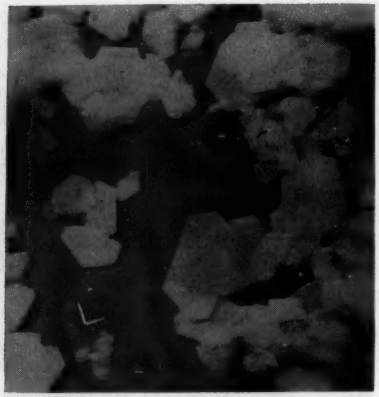

Figure 3. Kaolin at 12,000 X.

Figures 2a and 2b are electron micrographs of a clay particle only about one quarter the average size of those shown in Figure 1. However, they give much more information on the structure of the particle. Figure 2a shows that flat sheets of material are piled one on top of the other, much like a deck of cards, to make up the particle. Figure 2b, a picture of the same piece of clay rotated through 90°, reveals that these sheets have hexagonal edges, indicating that they are formed by a mosaic of hexagonal plates.

Figure 3 shows the nature of some kaolin particles that are only about 1/25 the size of those pictured in Figure 1. These would appear only as vague points of light in the optical microscope. However, the electron microscope reveals that they are flat, hexagonal crystal plates. Thus it may be seen that the electron microscope both provides more details of the structure of things large enough to be seen with the optical microscope and reveals the nature of things too small to be seen by it.

Techniques Employed

The next series of electron micrographs have been chosen to illustrate the tech-

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LONG-TERM LOAD TEST OF A RING-CONNECTOR TRUSS DESIGN

By M. W. JACKSON*

Last May the author discussed the results of a long-term load test of nailed construction. In the following article he presents data and conclusions from a similar test of ring-connector design.

In general, timber design data have been compiled largely from standard tests of isolated joints and simple test specimens. There has long been a suspicion that results obtained from such tests may not be very reliable when compared with the behavior of an actual structure. Data obtained from testing machines have a shortcoming in that the full load does not remain on a yielding member but is temporarily relieved by the yield, perhaps allowing a gain in strength of the member. With increases in allowable loads on various types of timber fasteners within recent years, design loads in some cases have approached the proportional limit loads for the fasteners. As a result, the real factor of safety for a full-sized framed timber structure is an uncertain quantity.

In order to compare the behavior of a truss using TECO ring connectors with the theoretical design calculations, a pair of trusses were constructed using a typical design (No. 394, formerly included in *Typical Designs of Timber Structures*, Timber Engineering Company, Washington, D. C.). These trusses were of the Warren parallel-chord type, span 27 ft. They were placed seven feet apart, center to center, and braced together for mutual support. A two-inch plank roof was nailed to the top chord, and a waterproof roofing was applied. The plank roofers consisted of 12-ft. lengths, providing an overhang on the outside of the trusses and on the ends as protection from the weather. A photograph of the trusses in place is shown on the cover of this publication.

The trusses were allowed to remain in place a few days before added load was applied. A uniformly distributed load of 1½-in. to ½-in. crushed stone was applied in 3 increments. This size of stone provided a low rate of moisture absorption; the stone was exposed to rain, but the total load on the truss probably did not vary over three per cent due to the rain. Rainwater drained through the stone and off the roof rapidly. There was no snow load at any time.

Deflection measurements were made along the lower chords of the trusses on the outside of the trusses and were corrected for the effect of crushing at the supports. Deflections were measured from a steel wire stretched between fixed points by a weight. The gage points were scratch marks on the bolts. A mirror placed flat against the side of the truss was used to reflect the image of the wire for aligning the eye in reading a steel scale graduated to 0.01 inch.

The average midspan deflections of the trusses are plotted against time in Figure 1. It was not practicable to take deflection readings at regular time intervals. However, Figure 1 represents approximately 50 series of observations. The zero deflection was established with an initial load of 12 lbs. per sq. ft. on the truss. An additional load

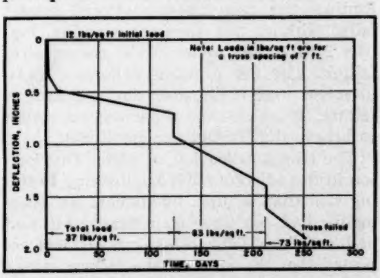

Figure 1. Average deflection of ring-connector truss at mid-span of lower chord.

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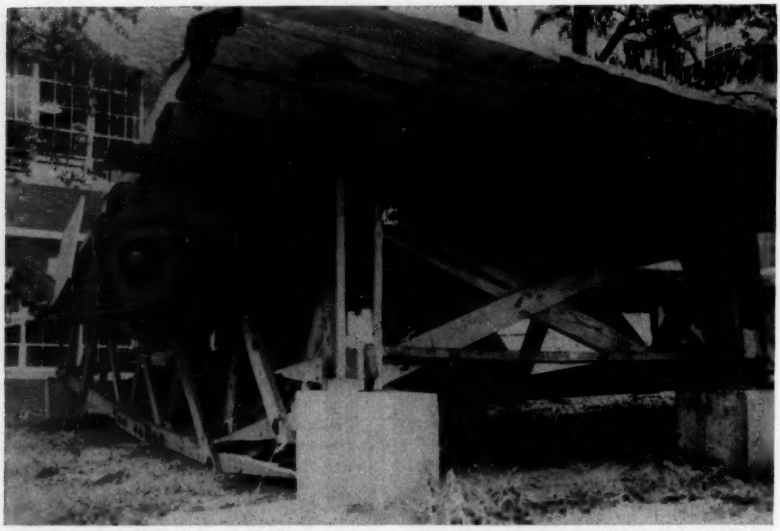

Figure 2. Failure of the east truss, as seen looking due south.

of 25 lbs. per sq. ft. was applied for a total load of 37 lbs. per sq. ft. for the first four months of the test. The measurements revealed an initial deflection of 0.33 inch, which continued to increase until it had reached 0.70 in. at the end of 122 days. This continuing deflection of the truss was not unexpected, since such behavior is inherent in all timber construction. Additional load-deflection measurements are shown in Figure 1.

After a total elapsed time of 254 days of loading, the two ring-connectored trusses failed without any apparent warning. Figures 2 to 7 show views of the trusses after failure. The last previous deflection measurements were made seven days previous to failure, at which time there was no reason to believe that failure was imminent.

The trusses failed late at night. One person in the adjacent Civil Engineering Building said that, at first, he thought an automobile had run away on a nearby hill and had run into some other cars. It was reported that the noise of the failure caused students in nearby fraternity houses to pour out in their pajamas, shorts, etc., as if it were a big fire. The weather at the time was warm, clear and balmy.

This truss design, originally published about 1942, called for a total live load plus dead load of 50 lbs. per sq. ft. However, the duration of this load was not specified. On that basis, the load at failure represented a factor of safety of approximately 1.5. Since 1942 there has been considerable change in standards of ring-connector design, and this particular truss is no longer published by the Timber Engineering Company in its *Typical Designs*. On the basis of present standards, the lower chord joint probably represents the weakest point in the truss. The end distance is below the minimum permissible, and for this distance probably only 60 per cent of the normal allowable connector load would be permitted. Thus, the allowable load for the truss would be approximately 37 lbs. per sq. ft. for the duration tested. If the truss were designed on the basis of present standards, the load at failure would represent a factor of safety of approximately 2. It is probable that the end diagonal of the lower chord failed first and the chord failures are the result of bending introduced into the members by

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AEROSOL STUDIES AT GEORGIA TECH

By J. M. DALLAVALLE* *and* J. C. LANE**

To the average man the word "aerosol" probably conjures up the picture of a "bug bomb" and little else. Yet he is constantly surrounded by many aerosols, some desirable, some not. The following article discusses aerosols as factors of our environment and explains how new knowledge of their behavior is permitting us to minimize their bad effects and to capitalize on their good effects—from controlling rainfall to preventing and treating disease.

Some investigators believe the term "aerosol" should be limited to solid or liquid particles which will remain permanently suspended in air. Others would extend it to include particles which settle in accordance with Stokes' law, as well as those which are in random (Brownian) motion. In this article we shall avoid a rigorous definition and shall consider as an aerosol any particle present in air.

Man's interest in aerosols centers largely around their meteorological, atmospheric contamination and physiological effects. In some cases they are a definite nuisance and, possibly, a health hazard. In other cases they are a natural part of our environment, contributing to the beauty and livability of our planet. The meteorological phenomena involving aerosols include the sky's color at dawn and twilight, fog, clouds, rain, snow and hail. Lately Man has developed means of treating the atmosphere with aerosols to induce needed precipitation. The atmospheric contamination aspects of aerosols include airborne particles from volcanic eruptions, dust storms, smog, smoke and fumes. Pneumoconiosis, an inclusive term for diseases of the respiratory system (such as silicosis and anthracosis) is one of the physiological disturbances caused by aerosols. Airborne bacteria and spores constitute other physiologically harmful aerosols. Yet, somewhat paradoxically, other aerosols are now being used to prevent and cure human ills.

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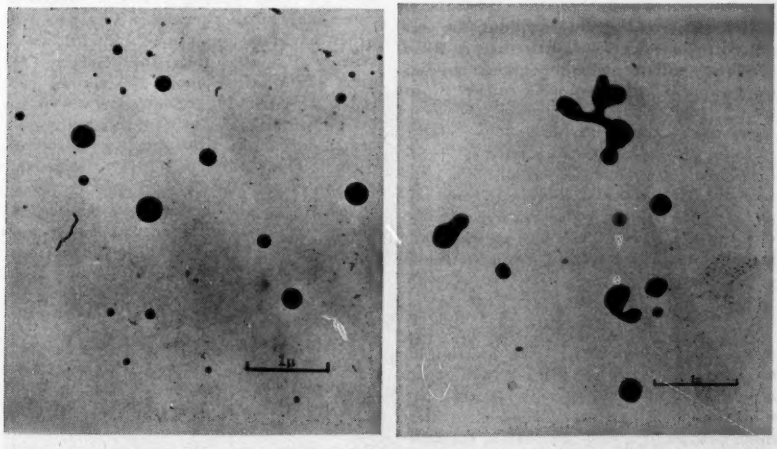

Figures 1 and 2. Ammonium chloride particles exposed to air of 22 per cent and 40 per cent relative humidity.

The many aspects of aerosol phenomena cannot be covered fully in a brief article. We shall, therefore, concern ourselves here with a short discussion of the three broad categories into which aerosol phenomena fall and conclude each with some review of the research now being conducted in these fields by the State Engineering Experiment Station of Georgia Institute of Technology.

METEOROLOGICAL ASPECTS

Aerosols diffract, reflect and absorb light rays, those in the air being responsible for the deep reds and yellows observed at dawn and twilight when the sun is at a small angle to the horizon. After the violent eruption of Krakatoa in the late 1880's, unusually variegated sunsets were noted for many years. While the blueness of the sky is attributed primarily, by the Rayleigh theory, to the effects of gaseous molecules, it is not difficult to demonstrate that aerosols approaching molecular dimensions will appear blue by transmitted light.

Both fogs and clouds may be considered as composed of small spheres of water vapor approximately one micron (about 40 millionths of an inch) in diameter. They remain stable if the air in the cloud or fog is saturated with water vapor or if the condensed spheres are solidified (ice) due to the low temperature of the atmosphere. Certain meteorological conditions are required to produce rainfall. In nature these conditions usually come about when a cloud meets a cold air front or is compelled to rise to higher, colder altitudes by some topographical cause. However, it is possible to induce precipitation artificially by "seeding" clouds with another aerosol. This relatively new technique of, to some extent, controlling our weather is of sufficient interest scientifically, economically and politically to merit much more discussion than can be given here.

Artificial Rainmaking

On any given day it is likely that some people in an area are praying for rain to aid their crops or to break a hot spell, while others, possibly in the very same area, are hoping for continued fair weather to bless some outdoor function. Therefore, the rainmaker may find himself in the familiar position of being unable to please all of the people all of the time. Last spring such a case in the state of Washington took a rather humorous turn. A group of farmers hired an airplane to seed clouds in their area for the purpose of providing rain needed for their particular crops. However, fruit growers in the same area strongly desired continuance of the dry spell to prevent too rapid growth and splitting of their cherries. They paid another pilot to fly along behind the first plane and "overseed" the clouds, a technique which quite effectively prevents precipitation.

There are several theories regarding the effect of one aerosol on another, and seeding of clouds is not exactly a new idea. As early as the turn of the century, attempts to induce rainfall were meeting with some success. Clouds are normally electrically neutral, and the introduction of positively charged finely divided quartz causes an instability tending to produce precipitation. This was the method favored in the early 1920's, by which time the airplane had been sufficiently developed to carry enough load to cover a relatively large area. Detonations of explosives introduced into a cloud have also been tried, but only limited success has been reported.

Silver iodide, the aerosol currently most used for cloud seeding, can be produced as exceedingly small particles, a single seed of which is about one one-hundredth of a micron (0.0000004 inch) in diameter. One gram can produce about 10^{18} aerosol particles, each of which can act as a nucleus for the condensation of water vapor. As the resulting droplets grow by continued condensation, general instability develops and precipitation usually results.

Rain may also be induced by seeding clouds with dry ice. In returning to its normally gaseous state, the dry ice extracts heat from the cloud, causing localized cooling to a temperature where condensation occurs.

Georgia Tech Studies

Fundamental research on the causes of aggregation of aerosols has been under way at Georgia Institute of Technology for about a year. The work has primarily been directed toward study of those factors affecting the stability of an aerosol cloud. The effect

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APPLICATIONS OF THE ELECTRON MICROSCOPE

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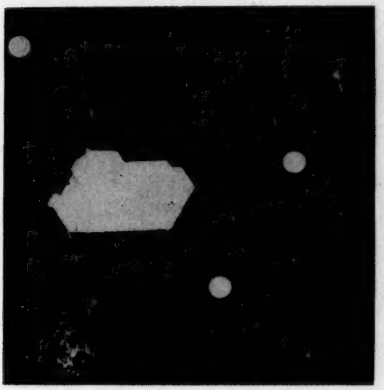


Figure 4. Gold-shadowed kaolin—14,000 X.

niques of preparation which are required for various types of material. Figure 4 shows a particle of kaolin surrounded by latex calibration spheres which, being of a standard size, make it possible to determine easily the magnification of the picture. This micrograph also illustrates use of the metallic vapor shadow-casting technique described in the previous article. By measuring the length of the shadow cast by a sphere, the shadowing angle is determined. Knowing this angle, one can readily determine the thickness of the sample by measuring the length of its shadow.

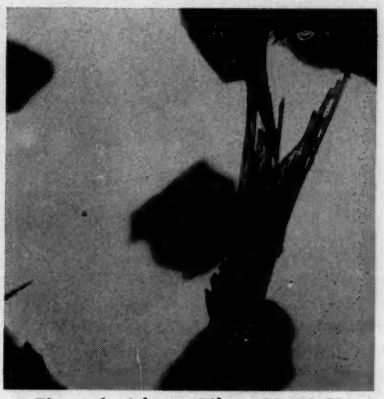


Figure 6. Asbestos Fiber—12,000 X.

Figure 5 shows the structure of the smoke produced by burning magnesium ribbon in air. As can be seen, the basic form is cubical, and the magnesium oxide particles occur in a variety of sizes. There appears to be a tendency for the cubes to attach themselves together in a string-like fashion. The sample was prepared by allowing the smoke to fall on a suitably prepared subtrate.

The structure of asbestos fiber is clearly

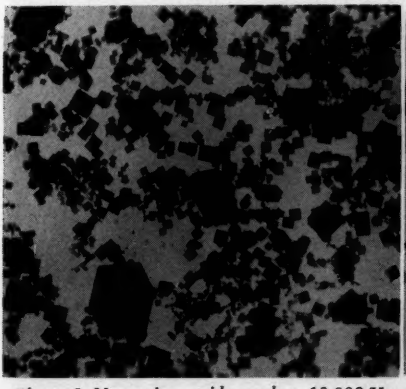


Figure 5. Magnesium oxide smoke—13,000 X.

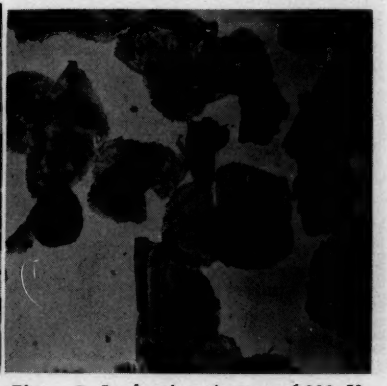


Figure 7. Lead paint pigment—6,000 X.

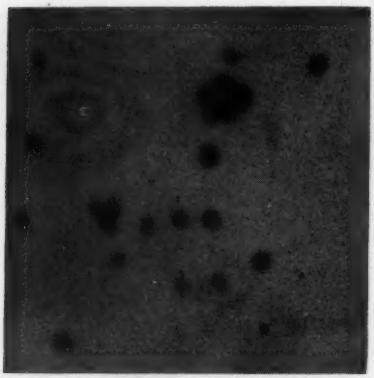


Figure 8. Particles in gold sol—100,000 X.

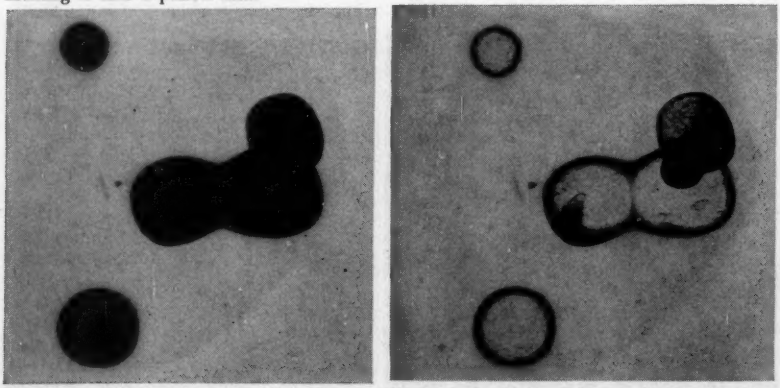
shown in Figure 6. Note particularly the small rod-like crystals that make up the fiber. Here sample preparation consisted of dropping several small pieces of asbestos on a suitably prepared substrate and then blowing off most of it.

The nature of a lead paint pigment is shown in Figure 7. Preparation of the specimen for this micrograph was somewhat more complicated than for the preceding ones, since the dry pigment would not disperse sufficiently for it to be viewed and it could not be suspended in water because of possible chemical change. It was dispersed by mulling it into a plastic film.

It must be admitted that Figure 8, which is an electron micrograph of the particles that make up a colloidal solution of gold, is not particularly impressive when viewed from the standpoint of a photographer. However, when it is understood that each blurred dot is composed of only a few hundred atoms of gold, the micrograph becomes considerably more interesting. If the page you are now reading were magnified the same amount, it would cover about 200 square miles.

The local heating caused by passage of the electron beam through the sample affects some substances rather drastically. Figures 9a and 9b show a group of ammonium chloride particles at the beginning and the end of a three minute exposure to the beam. As can be seen in Figure 9a, the particles were quite opaque to the beam at first. Later they were quite transparent, as shown in Figure 9b. Apparently heat from the electron beam's passage caused evaporation of the water of crystallization so that only a shell was left of each crystal.

The rather interesting shapes that stretched strands of rubber cement assume are shown in Figure 10. The connecting fibers between the nodules are approximately one millionth of an inch in diameter. The sample was prepared by simply pulling some strands across a supporting wire mesh.



Figures 9 and 9a. Ammonium chloride particles before and after electron bombardment—18,000 X.

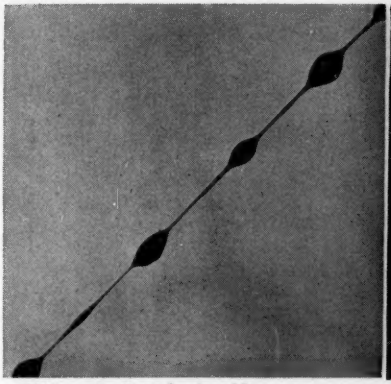


Figure 10. Strand of rubber cement—10,000 X.

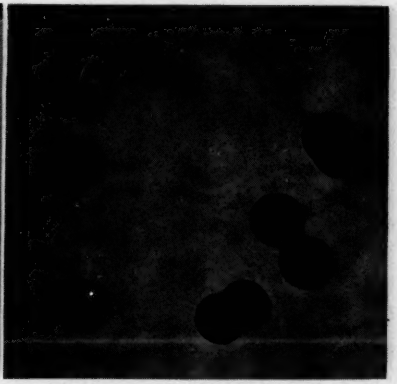
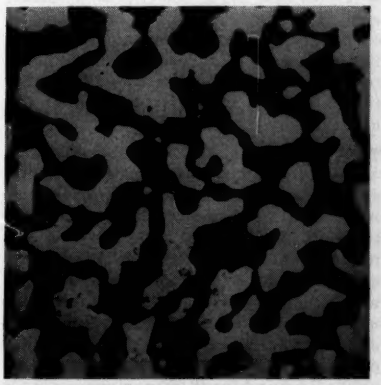
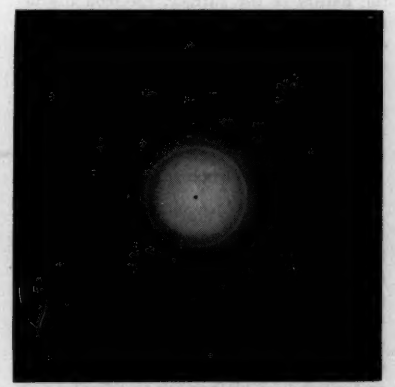


Figure 11. Stearic acid aerosol—9,000 X.

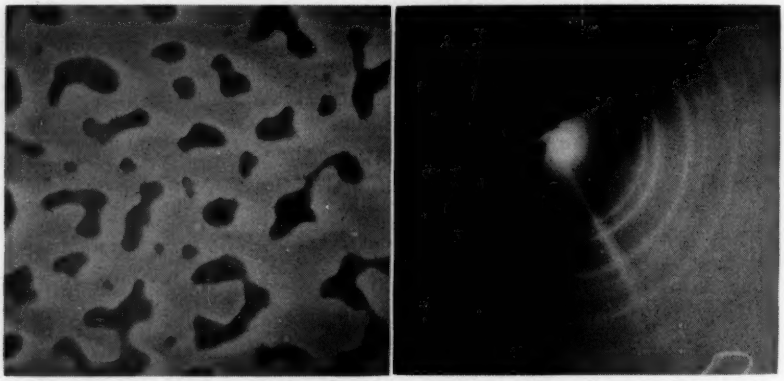
Some aerosols present a problem in viewing with the electron microscope, since the sampling process disturbs the conditions of the system, causing dispersion or concentration of the sample as compared with the free aerosol. In certain cases, this problem can be overcome by using a thermal precipitator consisting of a thin wire heated to a temperature greater than the ambient temperature of the aerosol. When the aerosol is passed near the thermal precipitator, heat from the wire gives the particles greater motion in a given direction and thereby aids their collection on a sampling screen. The motion imparted is usually gentle enough not to upset the conditions of the aerosol system. Figure 11 shows particles of a stearic acid aerosol deposited by this means.

The next two illustrations show something of the techniques that can be used in the study of very thin metallic films. In addition to a micrograph of the film that shows its physical features, electron diffraction patterns can be made that give information about the actual crystal arrangement within the film. Figure 12a shows an electron micrograph of a very thin film of





Figures 12 and 12a. Electron micrograph (at 24,000 X) and electron diffraction pattern of thin gold film on silica monoxide.



Figures 13 and 13a. Micrograph (at 6,000 X) of a positive replica of a thin gold film and reflection electron diffraction pattern of a gold film.

gold evaporated on a silicon monoxide substrate. Figure 12b is a transmission electron diffraction pattern of the same gold film. The number and spacing of the concentric circles indicates the type and arrangement of the crystals that make up the film.

When a metallic body is too thick for penetration by the electron beam to form the usual transmission picture, the nature of its surface can often be determined by a different approach. A thin plastic replica of the surface can be made and viewed in the microscope to obtain an indication of the nature of the surface. Electron diffraction patterns can be made by allowing the electron beam to fall on the metal surface at grazing incidences. The slight irregularities of the surface are sufficient to form the pattern. Figure 13a shows the nature of the surface of a thick film of gold evaporated onto glass. A plastic replica was made of the surface and then side shadowed with gold to increase the contrast. Figure 13b is a reflection electron diffraction pattern made from the same gold surface. The sample itself shielded the photographic plate from half of the pattern so only a series of concentric semicircles are seen.

While not representing all of the possible applications of the electron microscope, the foregoing illustrations should give some idea of its usefulness. The field of electron microscopy is relatively new, and progress is continuously being made, both in refinements of the instrument and improvements of specimen-preparation techniques. Pictures that once seemed impossible are now being taken, and there is strong promise of continued progress in the exploration of the lower-size-limit frontier.

UNIVERSITY RESEARCH

Continued from Page 4

If we assume that inflation has cut the value of the research dollar in half, we find that the research load, on a man-hour basis, and the number of men employed in research have both increased three-fold. There are strong indications that this is our current, manpower-limited capacity to prosecute research.

How bad is the research manpower shortage and what are the prospects of relieving it? Much study has been devoted to these two questions. A June, 1951, survey of the needs of 378 companies and government agencies indicated that about 80,000 engineers are needed now, *exclusive of the needs of the military*. The report went on to state, and I quote, "when the current graduating class of 38,000 is absorbed, there is still an unfilled demand for 42,000 engineering graduates. However, a recent survey of the 1951

class of engineering graduates showed that the military, through ROTC and reserve programs and through the selective service system, will siphon off about 19,000 engineering graduates. The actual unfilled demand will then be far more than 60,000 engineers." I believe you can see from this quotation that the defense industries face a tremendous problem. Half of the engineering school graduates are being taken into the Services, one way or another. This means that as far as filling the demand for engineers goes, we are taking two steps forward and one backward. On the one hand, our Government deplores the shortage of engineers, while on the other it makes it impossible for the colleges to produce a full crop. Sometimes I wonder if we aren't with Alice beyond the Looking Glass where we must "run awfully fast to stay in the same place."

Commenting on the survey I mentioned a moment ago, President Killian of M.I.T. recently had this to say: "Based upon present enrollments, estimates have been made which indicate that in 1954 we will turn out of our engineering schools from 12,000 to 16,000 students. This compares to an output just before World War II of some 20,000 engineers a year. The country's demand for engineers is greatly in excess of what it was before the war. Estimates now place the annual demand around 30,000."

The foregoing indicates the shortage of technically trained manpower, but I would like to emphasize that these figures, pitifully small as they are, are not truly representative of the *research* manpower shortage. The figures I have quoted also include the "garden variety" of engineer; that is, the Bachelor or Master without the specialized education, temperament, and initiative required in effective researchers. About all any of us can say about the research manpower situation is that it is bad and due to get worse unless the nation as a whole, and the Government in particular, back up our universities by recognizing the necessity for expanded enrollments and uninterrupted student attendance in programs extending through the highest levels of graduate work.

I am often asked whether I think universities should engage in research for the Armed Forces. To my mind that is a pointless question at this time. *Necessity* dictates that they must. The magnitude of our nation's defense research program requires maximum use of the fine minds available in the universities. We already have seen that the country's research capacity is limited by manpower, not dollars. Dr. Eric Walker, Executive Secretary of the Research and Development Board, recently estimated that 35,000 of the 130,000 persons in the country capable of performing research are employed by our colleges and universities. To complete the breakdown, 70,000 are employed by industry, and 25,000 by the Government. As a nation confronted with the prosecution of a gigantic military research program, we simply cannot afford not to make optimum use of these 35,000 potential researchers in our institutions of higher learning. Yet these men, distinguished by their ability to teach as well as to perform research, must not be taken away from the supremely important, longer-range function of educating the researchers of the future. Q.E.D., there is only one solution permitting the optimum use of both their teaching and research talents—that is to bring defense research onto the university campus.

Please understand, I do not advocate saddling the universities with "hardware" developments or testing programs, and I do not believe any educators advocate this. But there are a number of vital defense problems which require the cooperative efforts of researchers from several branches of science for their complete solution. The engineering research stations and research institutes maintained by universities have, in general, just the sort of diversified staffs and versatile laboratory facilities to tackle problems of such nature. Using popular terminology, it is a little hard to define just the type of problem I mean— perhaps "basic applied research" hits close to it. Where projects are even more basic, they may profitably be studied as part of the graduate education program, with candidates for advanced degrees as the investigators and faculty members in the fields of specialization as the research directors. As I see it, the universities can handle problems of these two types, basic-applied and basic, as well or better than any other agency whether in government or industry. I would say bet-

ter, myself, since the profit motive does not exist and, consequently, pressure is not brought to bear to produce preconceived results in an area where such is not possible. The university researcher's own background and that of his colleagues is broad enough that together they can often see practical applications of research results that likely would not be apparent to the industrial researcher working toward a specified goal.

A couple of minutes ago I said that I considered it pointless to ask whether universities *should* engage in military research, since the pressure of the times makes it *necessary* that they do. I did not mean to evade the question, and I would now like to point out some of the more often cited pros and cons of the subject. My comments will apply, in most cases, equally well to military research or industrial research, since both are sponsored and both tend toward the practical as contrasted with lily-pure research.

I will start with the "pros," because frankly I am a pro-sponsored-research man and I think I can make a better case for the advantages than for the disadvantages. Briefly, I am for sponsored research because it helps the universities get and hold top-flight men and it prevents withdrawal of teachers and students into completely abstract theory. The opportunity to perform research with some promise of eventual application holds many excellent men whose deep interest in the problems of industry might lead them to give up teaching if they were forced to choose between one or the other. Similarly, the opportunity to teach without abandoning research attracts men to universities who would not be willing to sacrifice the stimulus of research for straight teaching. Since university teachers like to have their families eat as well as anyone else, the fact that research contracts permit better salaries is another important advantage in building a strong faculty. This is very significant today when the shortage of competent men prompts industry and government to raid the universities for personnel. Research projects are also an effective preventive of "ivory towerism." They keep the thesis research work of the graduate programs from becoming sterile and purely academic. There is no doubt that the teacher who engages in research has to keep abreast of his field—right up in the front lines. This intellectual stimulus is passed on to his students who benefit accordingly.

To me, the disadvantages of sponsored research are more illusory than real, except that any good activity carried to the extreme tends to become a vice. Admittedly, it is possible for a faculty member to become so engrossed in research that he will neglect his teaching. The answer to this is simple—use him full-time on research and find another teacher. We get around this situation quite well, I think, at Georgia Tech by permitting the Engineering Experiment Station to hire faculty members part time as consultants or project directors in their field of specialty. These men are primarily teachers, but also researchers. The Station reciprocates by lending selected research personnel to the academic schools for advanced teaching in their specialties. They are primarily researchers, but also teachers. Naturally, the bulk of the Station's work is carried out by full-time researchers, but this interchange seems to act as a catalyst for both the educational program and the Station research program.

There is also the danger that applied research will become the tail that wags the dog as far as fundamental research goes. If I really believed this likely, I would change my attitude toward sponsored research in universities. However, I believe that it works the other way; namely, wherever considerable applied research is carried out, developments off the beaten path of the investigation in hand suggest promising avenues for basic research. In a university these can be pursued by the same research team or others, the result being more basic research rather than less. Also, basic concepts and new data coming from fundamental research on the campus can immediately be incorporated into applied research going on there. This eliminates the very considerable time lag in dissemination of basic research results through publications in the academic or technical journals. And, as you know, some theses lie embalmed, to all intents and purposes, in university libraries all over the world. In 1908 Paul Gelmo submitted a doctoral dissertation on the synthesis of para-aminobenzenesulfonamide from coal tar. It

wasn't until 1935 that his work was unearthed and given to the world as sulfanilamide. Correlation of research results and coordination of research effort is best attained where fundamental and applied research exist side by side. I believe we should have both in our universities.

I also believe, however, that there are some things that universities must guard against in taking on sponsored research. First and foremost is the potential loss of academic freedom when one accepts money to perform research. There has not been any pronounced tendency of Government or industry to dictate university policy, so far as I can say from our experiences at Georgia Tech. However, both Government and industry are prone to expect the attainment of a specified goal at a specified time. To point out the fallacy in this approach I would like to quote from Armour Research Foundation's pamphlet entitled "To Our Sponsors." I quote:

"To begin with, research takes time for fruition. Lots of it, as a rule. Things have to be done in logical sequence, and frequently the second step is not apparent until the results of the first are in. It's not a simple question of man-hours. Up to a certain point the job can be speeded up by increasing manpower; but beyond that point, if you expect to complete a research project by doubling the staff, then you might just as well try to cook a 3-minute egg in 1½ minutes by using two cooks. Furthermore, the total elapsed time for solving a problem depends upon the problem and bears absolutely no relationship to the personal wishes of the business man, his board of directors, or his sales and advertising departments."

Another disadvantage of undertaking sponsored research for the government is the fiscal procedure that must be followed. "Quadruplicate this" and "dozen copy that" run into a lot of red tape that cuts deeply into technical time that could be more usefully employed. This probably results from an attempt to make the sponsorship of research fit into a standardized legal governmental pattern developed for the procurement of material things.

A very real danger in sponsored research for the Government is posed by the efforts of some agencies to beat down the university's overhead to the point where it cannot cover the cost of carrying out the contract and, in effect, the university finds itself subsidizing the project. As you all know, university finances are on thin ice these days, and only the most highly endowed can afford to take on projects that threaten to be a liability rather than an asset. Most universities are deficit-operated anyway, and an increase in their scale of operations tends to increase the deficit.

I might also mention that since we took on a heavy program of sponsored research at Georgia Tech we have experienced a sharp dropping off in the number of publications per unit dollar volume of research conducted. This is partly explained by the security restrictions necessary in Government projects and the confidence in which work is often done for industrial sponsors. Nonetheless, it is a sacrifice for the individual researcher when he cannot publish his results, because his professional reputation is enhanced by such publications. A major function of universities is the dissemination of information. This has not been lost sight of at Georgia Tech; and, while the ratio of publications to total research has declined, we are still publishing as many papers and articles as before we took on a large defense research program—that is, we are keeping up our basic research and we are reporting it.

In spite of the disadvantages I have mentioned, I am, by and large, in favor of sponsored research in universities for the reasons cited earlier. I believe that in times of stress, such as the present, universities must give a more utilitarian type of service than is desirable in peacetime. But I feel strongly that the Government must be careful that it does not apply pressures on the universities which will impair their ability to do fundamental research, for that would be tantamount to draining dry the well into which it and industry must dip for basic knowledge.

Not the least of a university's problems when it decides to take on sponsored research is the development of a plan for organizing its activities and handling contractual details. This can be done in many ways, and volumes have been written on the subject. Research has many of the aspects

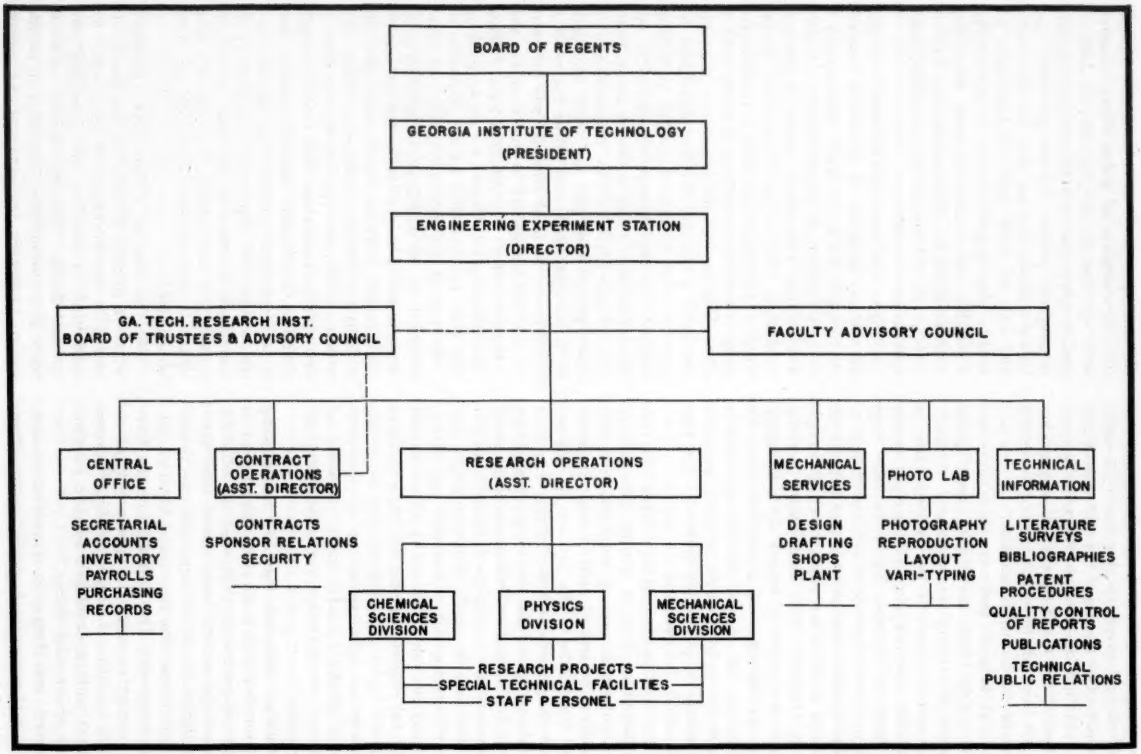


Figure 1. Organizational chart of the State Engineering Experiment Station, Georgia Institute of Technology.

of a business, and the man who heads it up should not only be a scientist in his own right but also an administrator, an executive, and a business man. He should have an understanding of human nature, a deep sympathy with the research worker, unlimited patience, tremendous energy, a keen financial sense, knowledge, and wisdom. Such men are rare, and a reasonable approximation is all that can be expected.

This top administrator should not be loaded with details, and he should have the faculty of knowing how to delegate both responsibility and the authority to carry it out. Scientific research talent being rare, each of the important scientists under the director should be given all the assistants he can use to relieve him as much as possible from detailed duties of a clerical, purchasing, designing, engineering, or technical nature.

While I do not claim that it is perfect, I would like to show you the organizational chart of the Georgia Tech Engineering Experiment Station to illustrate one way of organizing for handling sponsored research.

By this time, I hope I have left you with the impression that universities are making definite contributions to the national research effort in basic research, industrial research, and defense research. Specifically of interest to you will be the fact that universities are now conducting about 10 per cent of the nation's $1.1 billion military research program. The Engineering College Research Council recently published the results of a survey which indicates that defense research in universities can be increased by 60 per cent without detracting from the present level of non-defense research effort. I won't burden you with all of the data from which this conclusion was derived, but I will explain that of 20,000 faculty members reported by their institutions to be qualified to perform research, 8,000 are not now doing so. Putting them to work on research one-quarter time would raise the universities' contribution to 16 per cent. At present, each senior faculty member engaged in research directs, on the average, two graduate student assistants. Apparently a way of increasing the nation's research potential still further is to increase this ratio. The survey, which was prompted by the research manpower shortage, concludes with the statement that it is in the universities that the greatest potential for increasing our national research and development effort lies.

This last statement leads me to the part of this talk that I wish I could broadcast to every voter in the United States. That is this—your universities, their faculties, and, most particularly their students are important to our defense now and to our peacetime standard of living tomorrow. Yet many universities and colleges, particularly those which are privately supported, are beset with difficulties resulting from thoughtless or misguided legislation at the national level. Their finances are at an unprecedentedly low ebb and are sinking rapidly for three basic reasons:

(1) Inflation has increased the prices of everything they buy, while

(2) The Government policy of low interest rates has drastically cut their income from endowments, and

(3) The Federal income and inheritance tax policies have discouraged the flow of gifts and bequests from wealthy individuals.

While the policies mentioned were certainly not adopted to wreck our higher educational system, they are having that effect.

Recently, a carefully thought out plan to promote basic research in colleges and universities while, at the same time, enabling specially talented students to work for advanced degrees was approved by the Congress, given a small appropriation for organization, and then cut off short by the House of Representatives whose action eliminated funds with which to accomplish its purposes. I refer, of course, to the National Science Foundation which asked for $14 million and had its request sliced to $300,000 by representatives who apparently failed to grasp the significance of what they were doing. Men who would vote billions for defense blithely cut off a potential source of the research and research manpower which we need to develop tomorrow's weapons. Maybe we should arm them with bows and

arrows and send them to meet a Russian tank.

The draft policies adopted in World War II and now again during this war we are waging with Russian satellites have not only siphoned off the younger trained scientists who should form the active research group of tomorrow but also have prevented the training of the graduate students who should form the cadres for the day after tomorrow. And when the Armed Forces want reserve officers, they show no mercy to the colleges.

The important thought I want to leave with you is that the universities need research, and research needs the universities. As Congress becomes aware of this fact, I am sure many of our problems will be alleviated.

It is my hope that this presentation of the problems of the universities in their efforts to aid in these national research undertakings will help you in the important positions to which you will be called in the near future. It is most important that the top-ranking military personnel understand and exercise a sympathetic tolerance toward our universities and their efforts to train scientists and, at the same time, conduct research on military problems.

Figure 3. Failure of west truss (looking north).

Figure 4. View of lower chord joint at north end of east truss.

LOAD TEST

Continued from Page 8

the failure of that web member. The chord failures occurred at the weaker points along the chord where defects were present. The failure near the splice may have been the result of impact caused by the collapse of the truss.

The writer wishes to thank the Southern

Figure 4a. Another view of lower chord joint at north end of east truss.

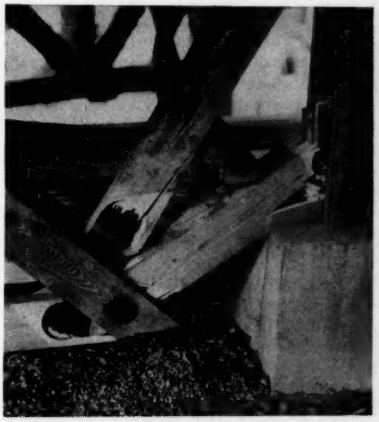


Figure 5. Lower chord joint, south end of west truss.

Pine Inspection Bureau for the services of a lumber inspector when the lumber used in the investigation was purchased and the Timber Engineering Company for donation of the rings used. This project was made possible in part through a grant-in-aid allocated by a research committee at the Georgia Institute of Technology from funds made available jointly by the Carnegie Foundation and Georgia Tech.

Figure 6. Top chord, east truss.

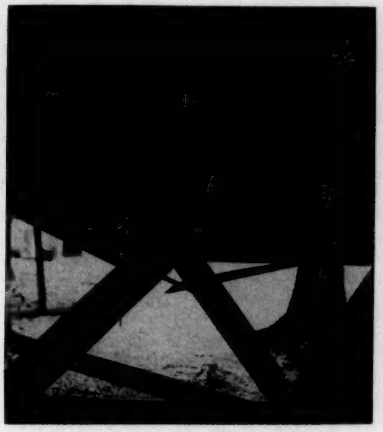


Figure 7. Top chord, west truss.

AEROSOL STUDIES

Continued from Page 10

of small traces of water vapor on the aggregation of ammonium chloride aerosols is shown in the electron micrographs presented herein as Figures 1 and 2. Similar effects have been observed with vapors having relatively high dipole moments.* On the other hand, vapors of carbon tetrachloride and benzene, neither of which has a dipole moment, have no aggregating effect.

This Georgia Tech work has two objectives: (1) to learn more about the factors influencing aerosol stability and (2) to determine whether the usual seeding methods can be used to "prepare" air prior to conventional cleaning in commercial equipment. The conventional cleaners are not very efficient in removing extremely fine contaminants, such as radioactive dusts and viruses, except where multiple-stage, bulky and costly units are used. If the contaminating aerosol can be made to agglomerate, removal of the resulting larger particles is no

*This does not necessarily mean that the vapor must possess a dipole moment only to be effective. The surface properties of the aerosol to be aggregated are also factors to be considered.

problem with existing equipment. There appears to be a possibility of cleaning air of noxious gases and vapors and even of purifying gas mixtures consisting of several components. Two patent applications have recently been filed.

ATMOSPHERIC EFFECTS

Smoke and smog are aerosol contaminants characteristic of modern civilization. The same is true of fumes, generally metallic oxides, which have their origins in industrial processes. Smog, a combination of smoke and fog, is responsible for the pall that hangs over thickly populated and industrial areas, especially in cool weather.

Smoke particles can be classified into two categories: (1) larger particles of cinder and carbon which settle as "nuisance dust" and (2) fine ash or other solid matter which is small enough to qualify as an aerosol. Nuisance dusts can cause damage but are fairly easily controlled. The finer dusts may cause respiratory discomfort and, since they diffuse rather rapidly, their effects may be felt over a considerable area.

Some degree of relief from smoke has been achieved by installing cyclones, other types of precipitators, etc., in the stacks of industrial plants. However, the large quantities of gases to be handled and the fact that commercial cleaners are not perfectly effective have proved complicating factors. Studies on the dispersion of smoke, a rather difficult problem in diffusion involving complicated mathematical analysis, have helped engineers in determining the effects of smoke particles in terms of stack height, average wind velocity profile and direction and topographical considerations. Thus, a potential contributor to atmospheric pollution can predetermine whether his plant will affect residential areas and can locate in the most suitable section. If the site of the plant can not be changed, at least he can erect a stack sufficiently high to minimize the nuisance his smoke creates. The maximum effect of a smoke cloud on objects at ground level occurs at 20 or more stack heights downwind. As a first approximation, the concentration at ground level (and considerable distances downwind of a stack) is roughly proportional to the wind velocity and the square of the distance.

Georgia Tech Studies

One of the main unsolved problems related to smoke and smog control is the rate at which these aerosols settle. Stokes' formula is applicable only so long as settling occurs in an atmosphere at constant temperature. However, a temperature gradient almost always exists between the ground and the upper atmosphere. A considerable amount of the work being conducted at Georgia Tech deals with study of these temperature gradients.

Smoke consists of more than just aerosols. Sulfur dioxide is one of smoke's most troublesome constituents, since it combines readily with moisture in the air to form sufurous acid. This acid, condensing on the surface of smoke's aerosol constituents, makes them quite corrosive. A conservative estimate set the United States loss due to corrosion at $3 billion in 1922, a figure dwarfed many times today. If only ten per cent is attributable to sulfurous acid, the figure still represents a sizeable drain on our economy. Strongly ionized aerosols are well-known fog producers, as anyone who has seen an oleum tank car unloaded can attest.

Undoubtedly there are numerous other gases which behave similarly to sulfur dioxide and sulfur trioxide. There is a need for research in this field, which Georgia Tech's Engineering Experiment Station is gradually filling. A survey of atmospheric dust in the Atlanta area is now under way. It is expected to last almost two years, and it will cover all significant aspects of the problem. It is hoped that field work, coupled with fundamental laboratory investigations, will yield a better understanding of what causes smog and how it can best be controlled.

PHYSIOLOGICAL ACTION

Except for diseases caused by airborne bacteria and allergies due to pollens, most health impairment from aerosols may be classed as industrial hazards. Dusts from quartz (silicon dioxide), asbestos and certain talcs may cause serious lung injuries if the exposure is prolonged. While other inert dusts can also cause harm, the exposure can be greater before injuries are noticed.

In general, few particles greater than 3 microns (0.00012 inch) can reside in the atmosphere for long periods. This explains why people living in deserts do not seem to contract silicosis. The wind action has long since elutriated the particles below the size which can be inhaled. Thus, the sand is "clean" and too large to enter the lungs and do damage.

Apparently smoke and smog normally do little more than irritate the respiratory tract. Mortality figures indicate that residents of cities are no more susceptible to respiratory ailments than their country cousins. However, situations have occurred (in the Liege Valley of Belgium in 1928 and in Donora, Pennsylvania, in 1949) where either high concentrations of aerosols or noxious gases (probably both) in the atmosphere were blamed for numerous fatalities. The precise cause has never been satisfactorily explained in either of the instances cited. Nevertheless, rare as they are, such occurrences must be guarded against.

In industry there is always the possibility that workers may inhale poisonous aerosols or dusts, such as the metal oxides (fumes). Because the lungs absorb such poisons and direct them immediately to the blood stream, their action is quicker and more serious than that of the same materials taken orally. In fact, the quantities leading to injury on inhalation would hardly have a noticeable effect when ingested. This greater activity has led to the use of aerosols for therapy. Good results have been obtained by the inhalation of penicillin dust instead of using the usual therapeutic procedures. The same is true in the use of aluminum dust to combat the effects of pneumoconiosis caused by siliceous dusts, especially quartz. In the latter case, however, the action is directed toward the injured lung rather than the blood stream, and it is probably a physical action only.

Georgia Tech Studies

The pollens can be considered as aerosols. Work in determining the true density of pollens was done here at the Experiment Station almost three years ago. They were found to be almost twice as heavy as was formerly supposed.

The study of air-borne bacteria is one of the Station's chief interests in the field of aerosols, since they are believed to be the major medium for propagation of epidemics. Their potentialities in bacteriological warfare are consequently great and must be given consideration in our defense plans. Work is now under way to accomplish the following objectives: (1) develop a sampling device which will give a true measurement of bacteria density in air, (2) discover a method for estimating the true settling rate of bacteria and vapors, and (3) determine the effect of various organic vapors on coalescence and destruction of bacteria.

SELLING RESEARCH

Continued from Page 2

There is a rather wide divergence of opinion, even among scientists, as to the minimum amount of basic research that must be conducted to provide the factual raw material essential for the prosecution of applied research at a constant rate over the long term. Some say as much as ten per cent; some, as little as one per cent. An average of five per cent is fairly generally accepted. If we agree on the five per cent figure, we find that $100 million of our total $2 billion per year research expenditure *should* be devoted to basic research. Otherwise we court the danger of becoming a nation of skillful copiers and adapters without the ability to invent for want of the basic knowledge required. Such a country is always a step or two behind—a condition undesirable in peacetime and fatal during a war.

This brings us to the burden of our editorial. There is substantial agreement that our fundamental research has been sadly neglected in the United States. Steps have recently been taken to ameliorate the situation by the establishment of the National Science Foundation. This body would make grants for basic research projects and would provide funds for fellowships in pure and applied science. Last year Congress granted the Foundation $225,000 for organizational expense with the understanding that it would make operational funds available

this year. However, on August 20 the House of Representatives cut the Foundation's request for $14 million by 98 per cent, contending that no real contribution could be made to the advancement of our fundamental knowledge during the period of uncertainty caused by our strained relations with Russia. Thus the problem of providing funds for basic research is no nearer solution than it was a year ago. Only that amount of basic research can be undertaken that can be supported by our financially pressed colleges and universities with what aid is made available by the contributions of business and industry.

The Nazis killed basic research in Germany by their race theories and political youth movements. We can only hope that our national legislature will awaken before it lets our basic research die from starvation.

ABOUT WALLACE J. MILLER

Wallace J. Miller

Wallace J. Miller decided to spend the early part of Thanksgiving Day afternoon working in his garden. At one o'clock he was stricken with a heart attack. Two and one-half hours later he died at Fort McPherson Army Hospital.

Wally Miller was only 47 when he died, but he had already lived a life fuller and more useful than many a septuagenarian. So we feel that we are not writing his obituary, but rather telling those who did not know him how we who did will always remember him.

The newspaper called him Rear Admiral Wallace J. Miller, U.S.N., Retired. He was that, and his record shows Annapolis, Class of 1926, World War II service as commander of Destroyer Division 100 under Vice Admiral Marc A. Mitscher and Fleet Admiral William H. Halsey, Pacific Fleet Electronics Operations Officer under Fleet Admiral Chester W. Nimitz and citations including the Legion of Merit. Before the war he originated the Navy's courses of instruction in radar and served as officer-in-charge of the Navy's Radio Material School. After the war he served as assistant director of the Naval Research Laboratory.

The newspaper also said he was Professor Miller of Georgia Tech's Electrical Engineering Department. He was that, a teacher whose competence and patience were respected by those who studied under him from 1947 through 1950, after which he took leave of absence to devote full time to Station research for his country's defense.

We knew Wally Miller primarily through his contributions to the State Engineering Experiment Station's growth and research progress. He served here as the administrator for electronics research projects conducted under the Physics Division. One of his major duties was that of project director on some very important defense research for the Navy. With Dr. James E. Boyd, he co-directed research and development of a specialized radar system for the Navy.

But Wally's greatest value to the Station was in his role of sage advisor and capable leader. His influence was felt in all of our divisions, and those of us who knew him well esteemed him both as a respected colleague and a loyal friend.

Wally Miller was a man of at least three professions—the Navy, research and education. He excelled in all three, and he was active in their societies. He was a member of the American Society for Engineering Education, a senior member of the Institute of Radio Engineers and 1950 chairman of the Atlanta Section of the I.R.E.

Brief though it was, Wally's life was full. He is survived by his wife, two married daughters and three grandchildren. We join them in honoring the memory of a man who was good in the fullest sense of the word.